MI Achievements in FY04

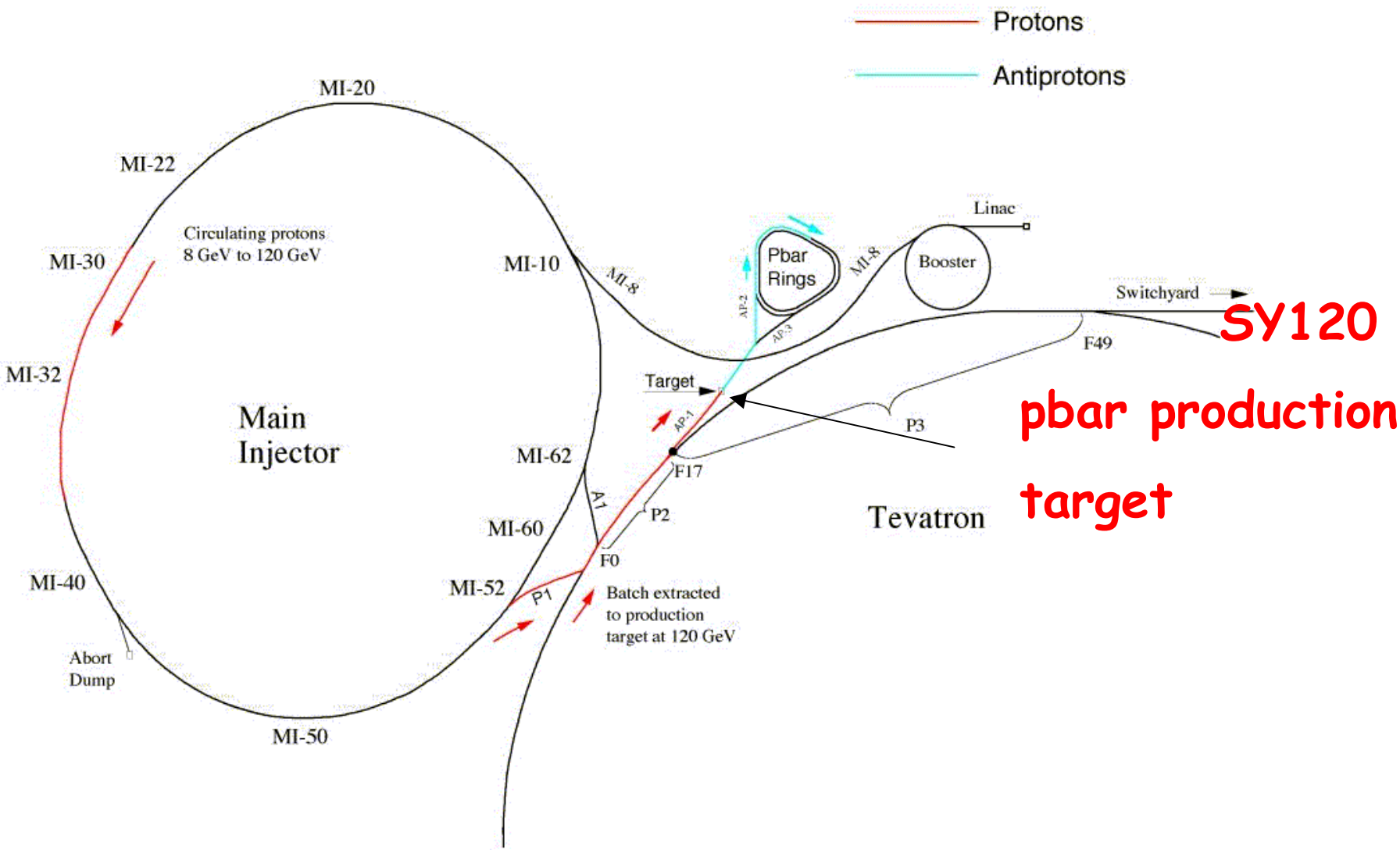
I. Kourbanis

Accelerator/MI

AEM

11/08/04

MAIN INJECTOR IN FY04



- **MI Bunch by Bunch Dampers**
- **Mixed Mode Pbar Transfers**
- **Slip Stacking**
- **SY120**

MI Bunch by Bunch Dampers

- The system consists of beam pickup signals (RWM, stripline) with corresponding kickers and a single digital board serving both transverse and longitudinal dampers
  - **pickup signals digitized at 212 MHz, with 12 bit resolution**
  - **digital pipelined processing in a large FPGA**
  - **damper kicks digitally synthesized by a 424 MHz DAC**
- FPGA prototype board installed in spring ’03
  - **first tested with transverse dampers**
    - **have been essential to achieve an intensity of 3.3×10^{13} in MI at 8 GeV**
  - **after ’03 shutdown longitudinal dampers have been made operational for proton transfers to the Tevatron and for pbar stacking cycles**
    - **Lead to a 25% Reduction of the longitudinal emittance after proton coalescing (15% decrease on bunch length).**

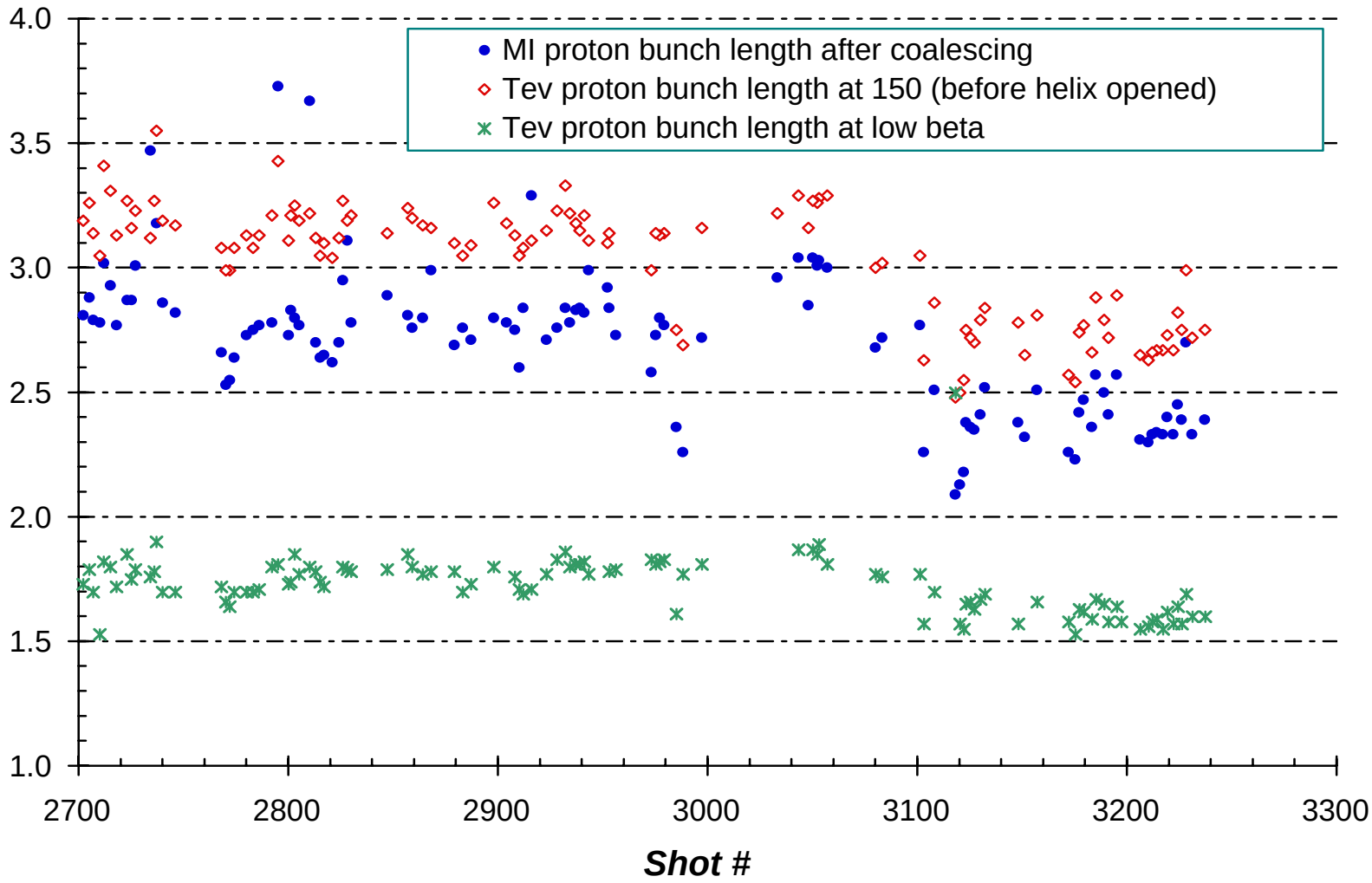
❖Final FPGA boards brought into operation in early summer ‘04

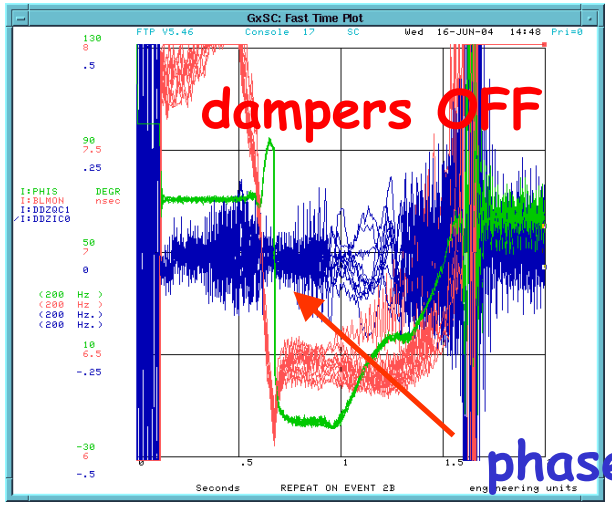
- ➢ **both transverse and longitudinal dampers implemented for 53 MHz bunches**
- ➢ **added code for transverse and longitudinal damping of 2.5 MHz bunches**

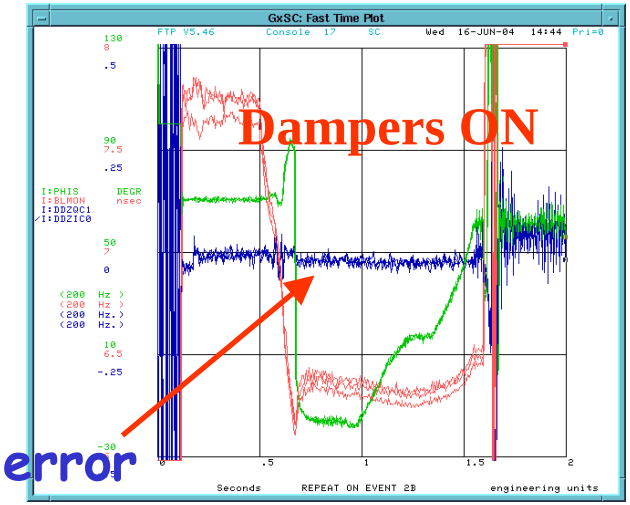
cycle	currently operational
pbar stacking cycle	53 MHz longitudinal
proton shots to Tevatron	53 MHz longitudinal
pbar shots to Tevatron	2.5 MHz longitudinal
2.5 MHz proton studies	2.5 MHz transverse and longitudinal
NuMI high intensity studies	53 MHz transverse and longitudinal

❖The plan is to come up after the shutdown with a system operational for all modes of operation

Effect of MI Bunch by Bunch Damper on Proton Coalescing





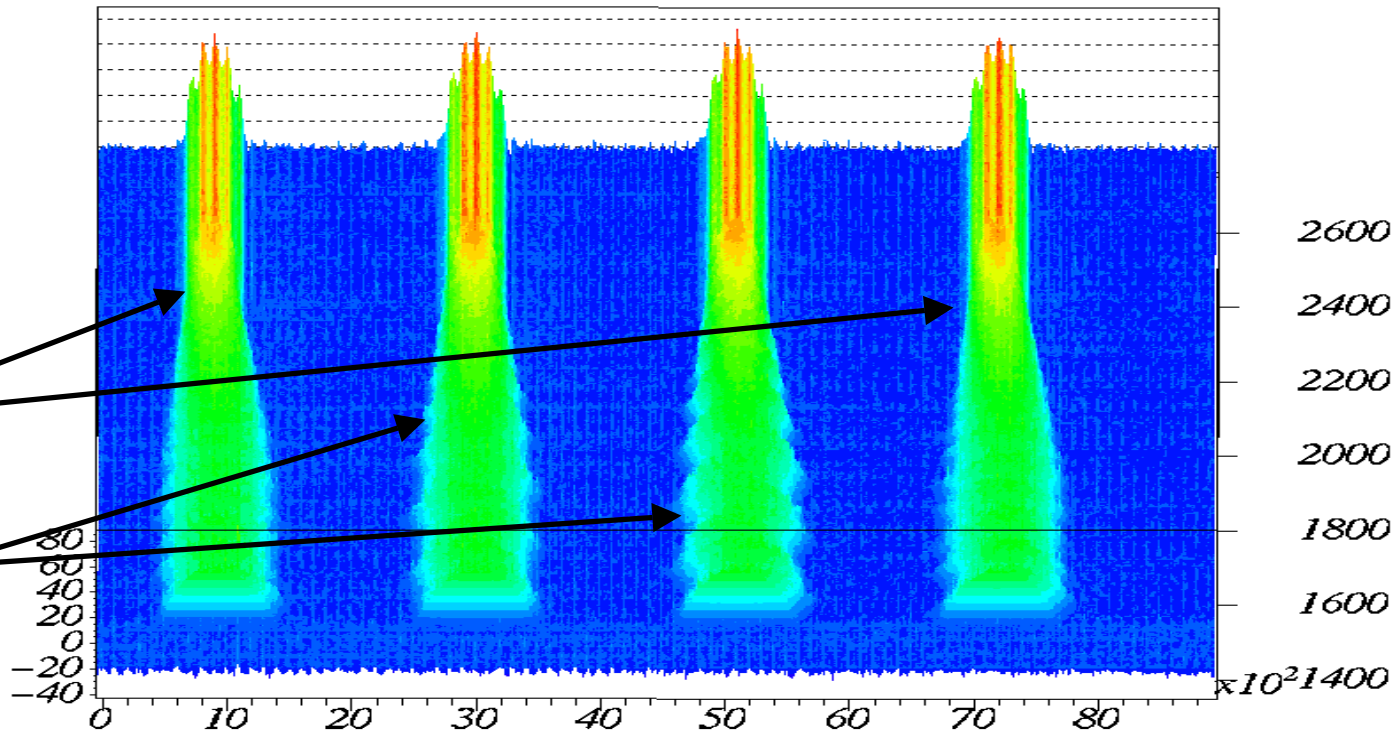


Proton shots to the Tevatron

2.5 MHz antiproton injection

Damped

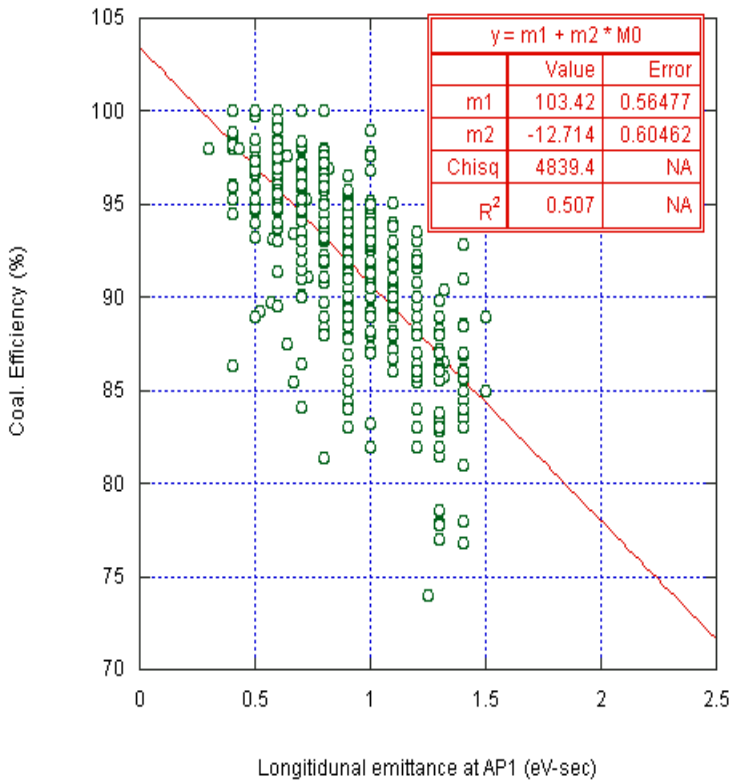
Not Damped



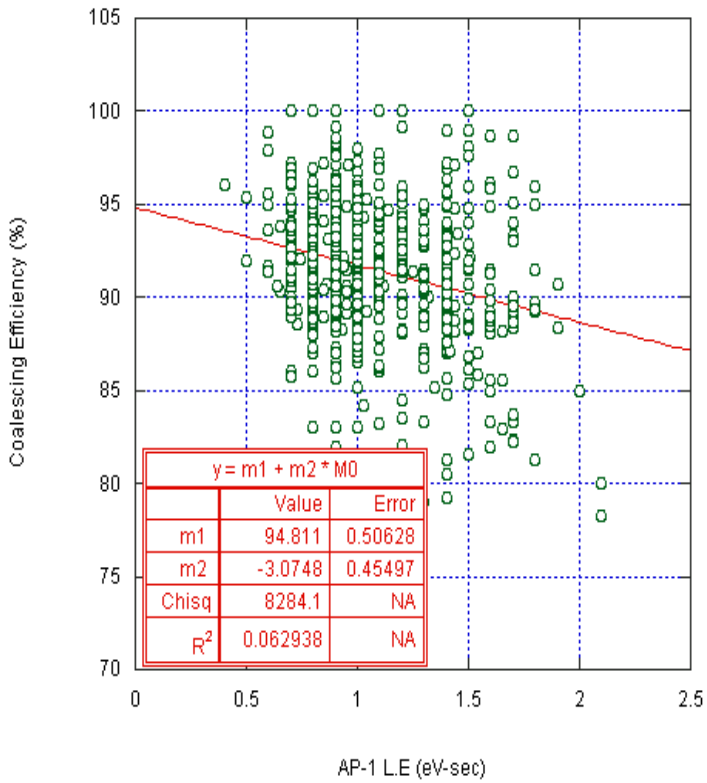
Mixed Mode Pbar Transfers

- Created the ramp(s) to accommodate pbar transfers from both the Accumulator and the Recycler (Different 8 GeV energies).
- Switched to 2.5 MHz transfers from the Accumulator.
- Used the 2.5 MHz voltage in MI to reduce the bunch length before recapturing in 53 MHz thus reducing the number of 53MHz bunches we had to coalesce.
  - Increase the coalescing efficiency for large longitudinal emittance bunches.
  - Effectively increased the number of pbars at TeV Injection by 7%.
  - Reduced the pbar bunch length after coalescing by 12%.

Pbar Coalescing Efficiency vs. Longitudinal Emittance

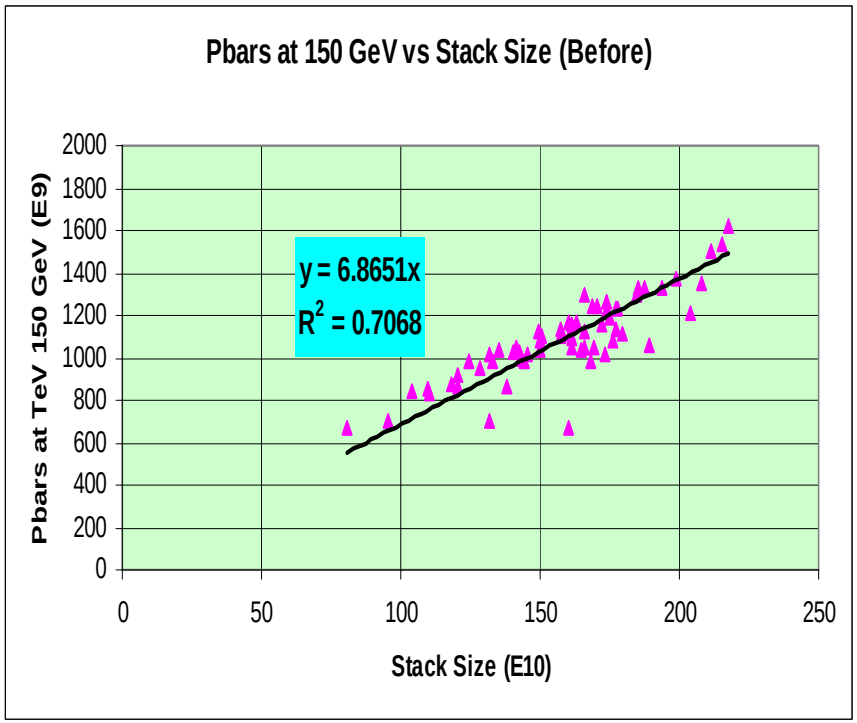


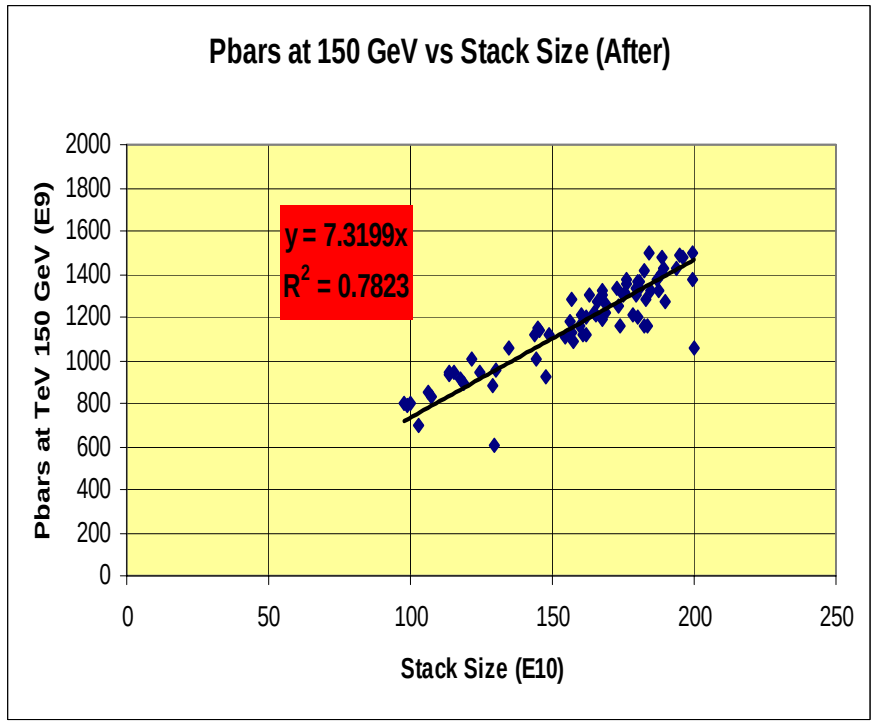
Before 2.5 MHz Transfers



After the 2.5 MHz Transfers

Pbars at TeV 150 GeV vs Stack Size

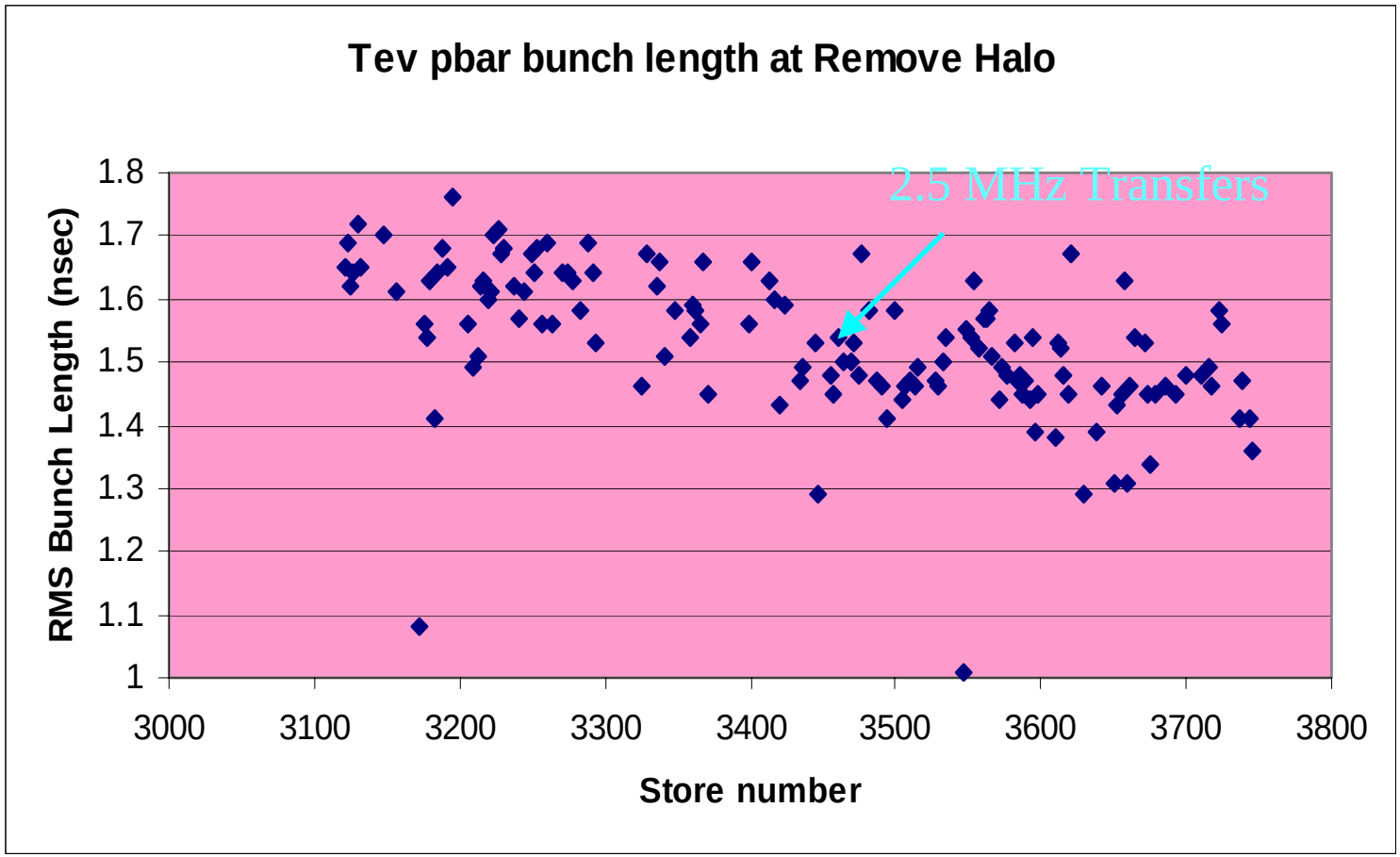




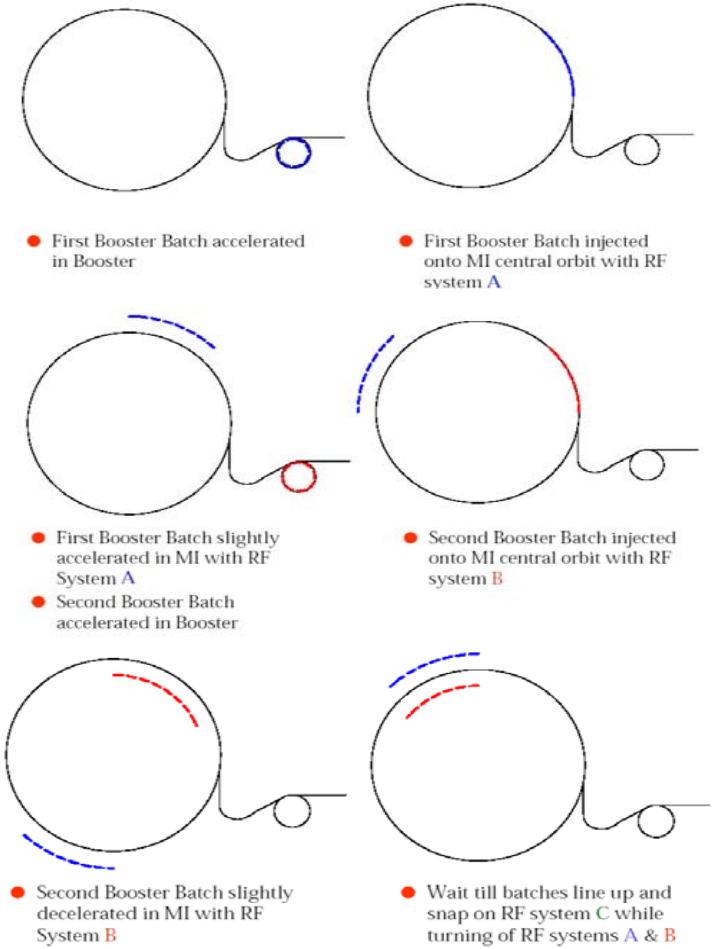
Before the 2.5 Mhz Pbar Transfers

After the 2.5 MHz Pbar Transfers

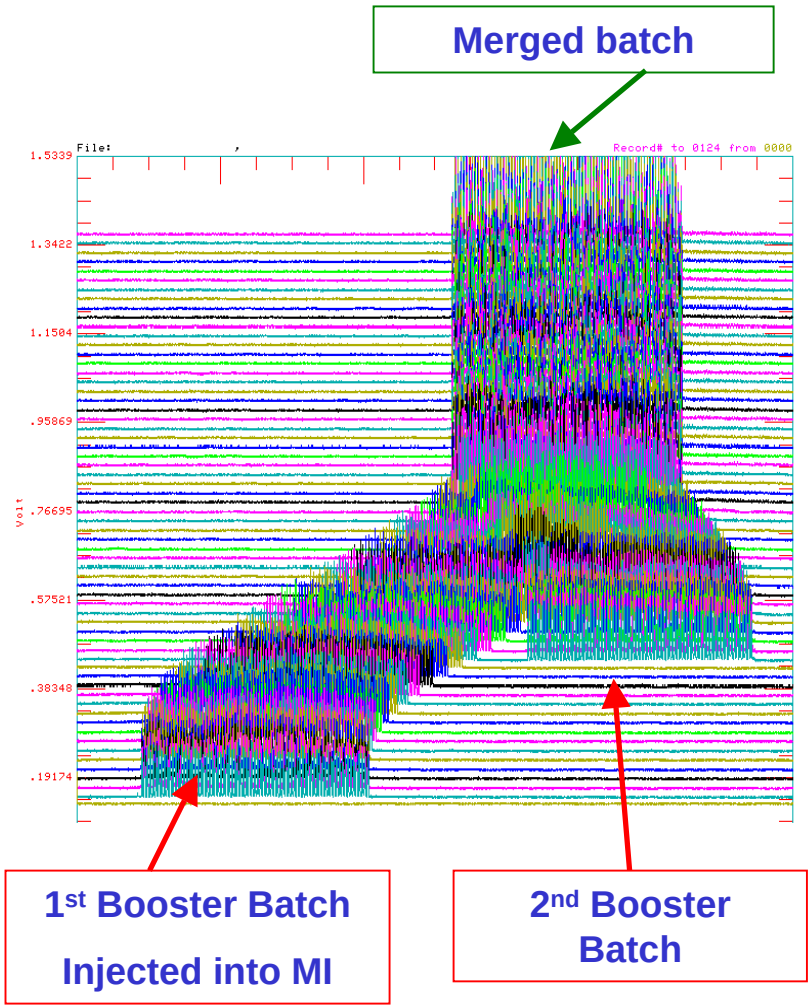
TeV pbar bunch Length vs Store Number



Slip Stacking in MI



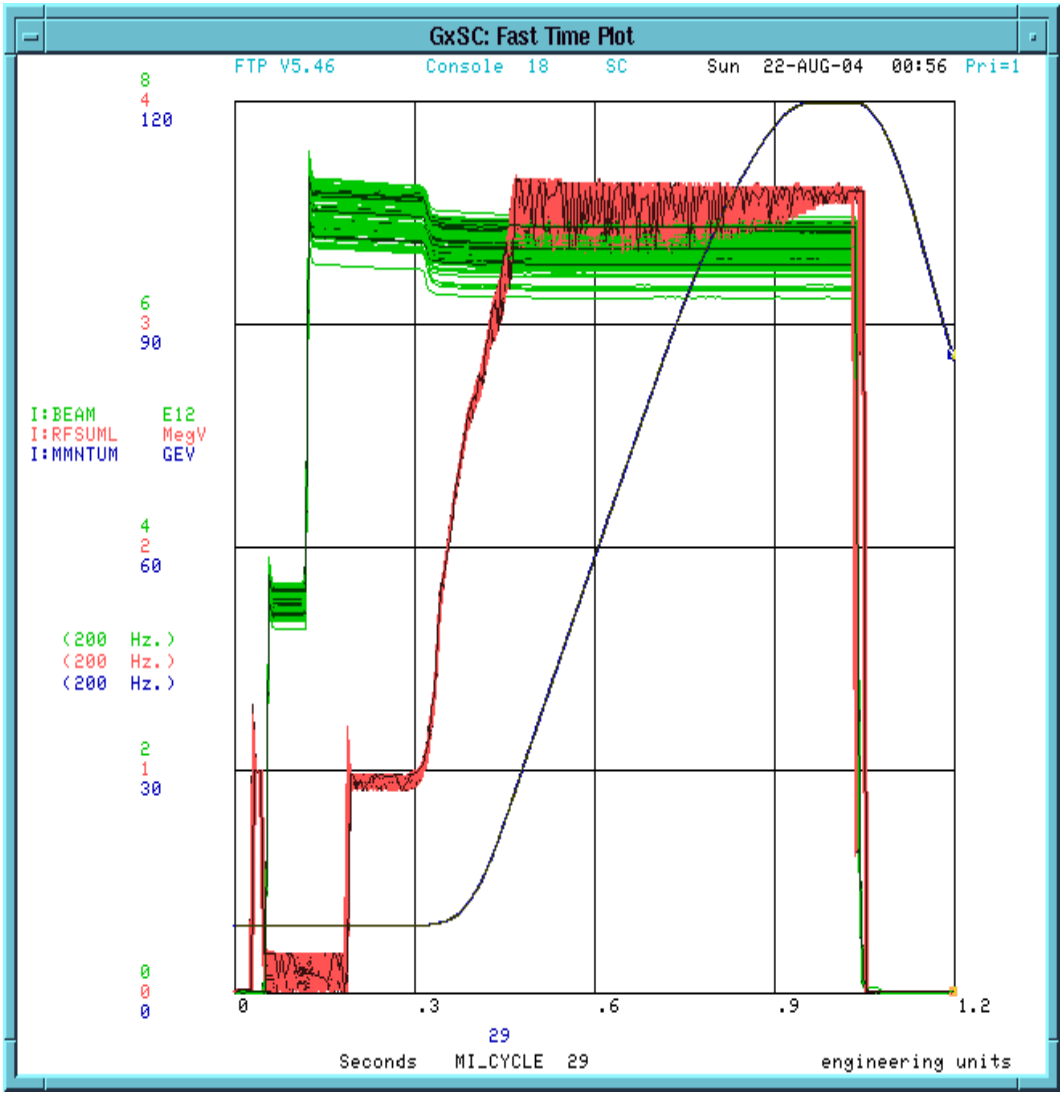
- First Booster Batch accelerated in Booster
- First Booster Batch injected onto MI central orbit with RF system A
- First Booster Batch slightly accelerated in MI with RF System A
- Second Booster Batch accelerated in Booster
- Second Booster Batch injected onto MI central orbit with RF system B
- Second Booster Batch slightly decelerated in MI with RF System B
- Wait till batches line up and snap on RF system C while turning of RF systems A & B



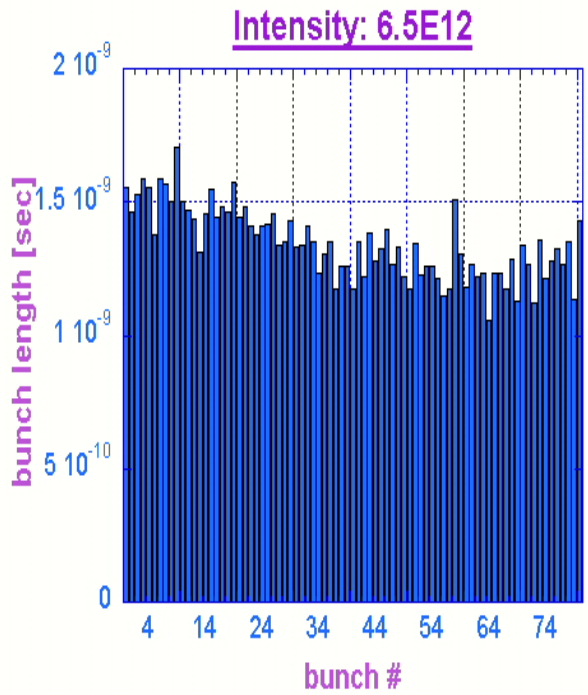
Slip Stacking Status

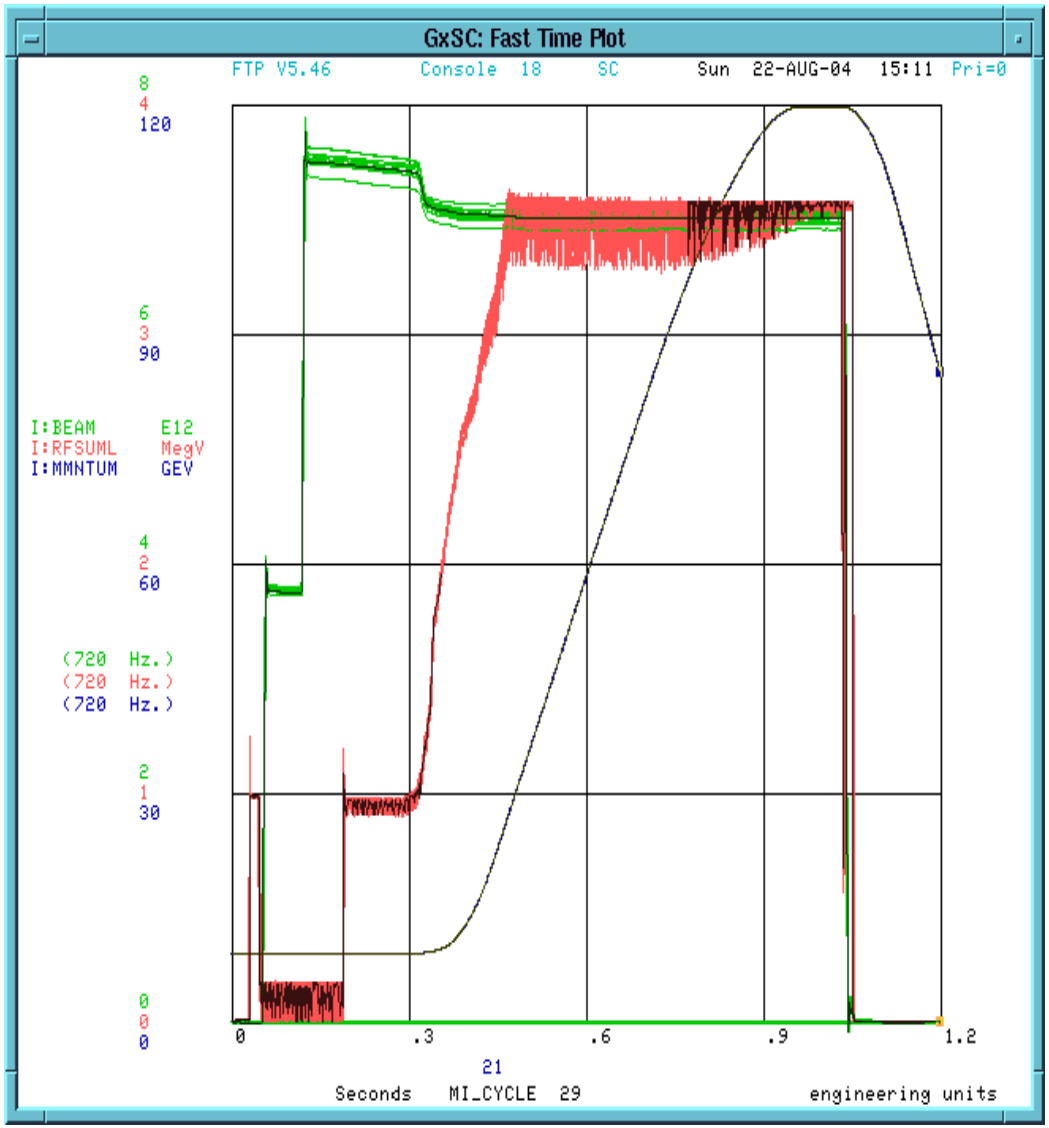
- All of the Solid State Amplifiers have been received and have been tested.
- A total of 12 rf stations have been upgraded so and are operational. The last six rf stations will be upgraded during the shut-down.
- Slip Stacking became operational during the last week before the shut down with typical intensities on the pbar target of 6.5E12 ppp (80% of Design). The bunch length on target was smaller than 1.5 nsec (95%) and the stacking rate was increased by 15%.

Beam Intensity and Bunch Length on Target for Slip Stacking

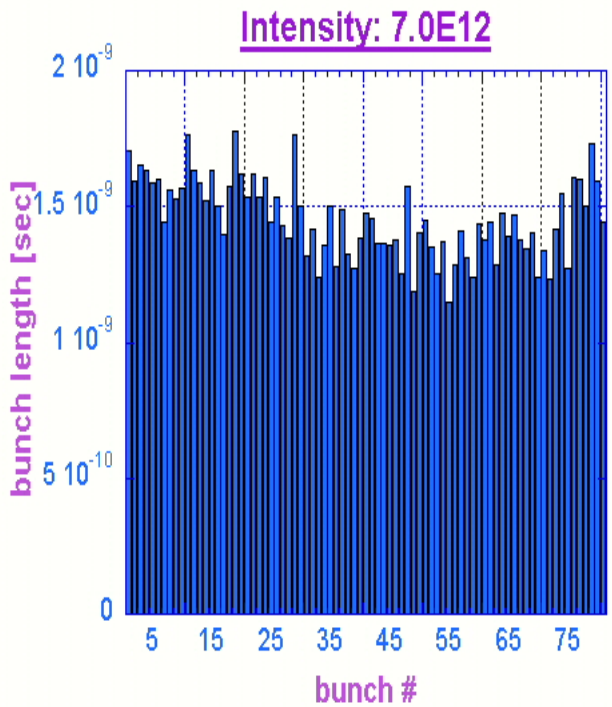


Bunch Length on Target

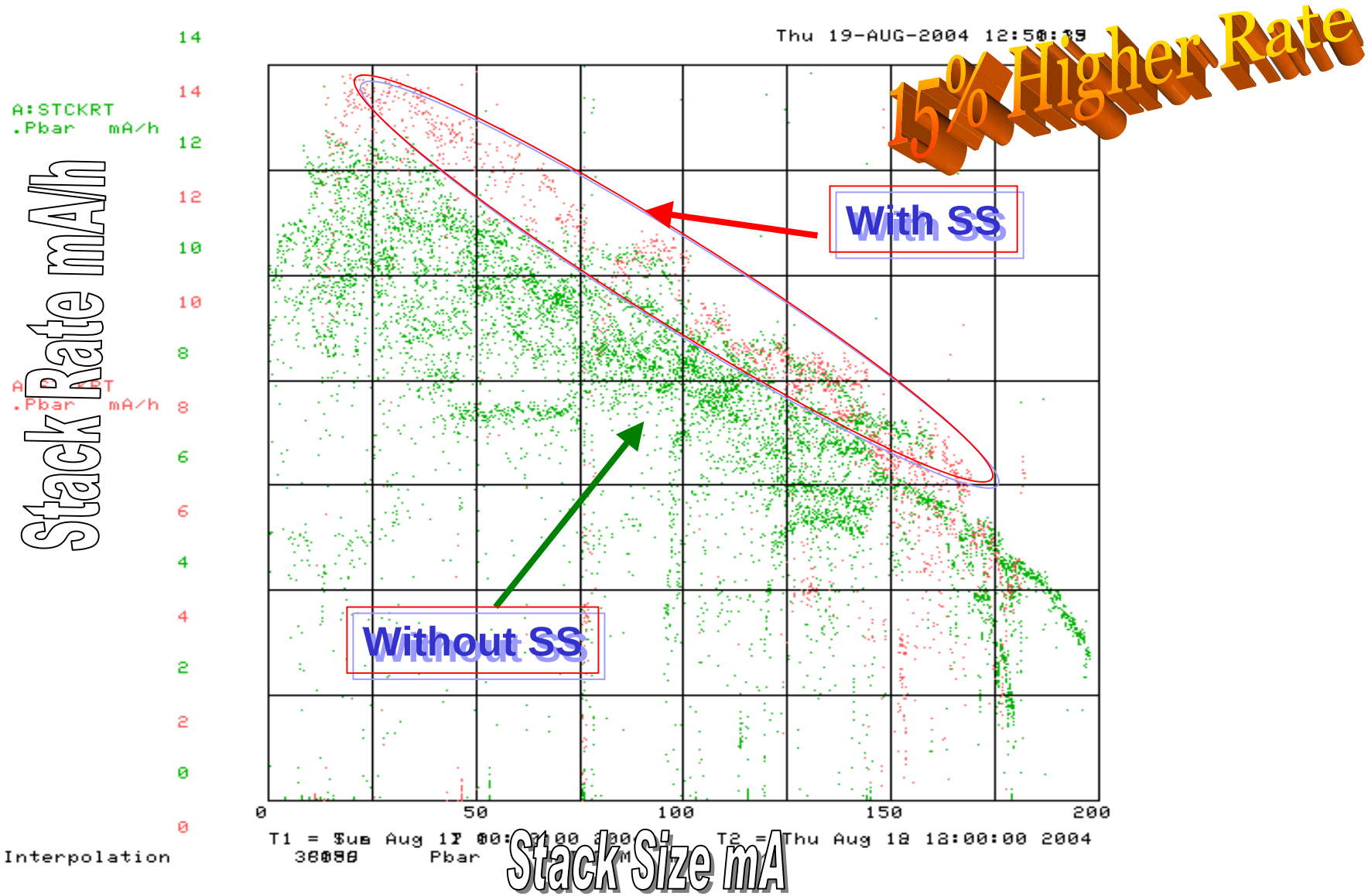




Bunch Length on Target



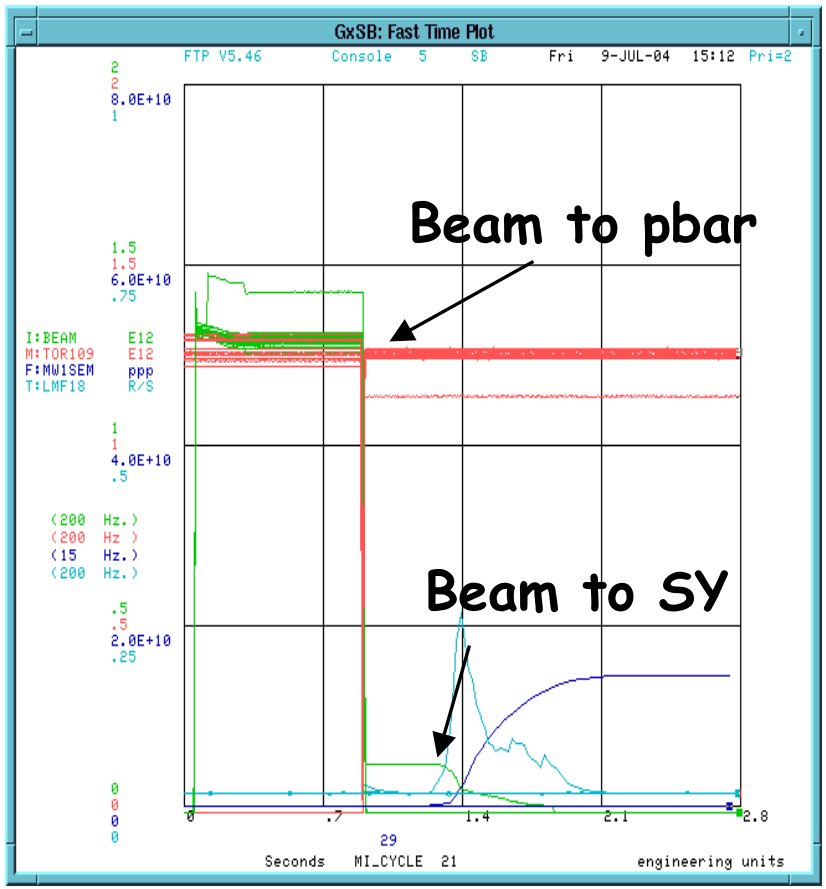
Effect of Slip-stacking On Pbar Stacking



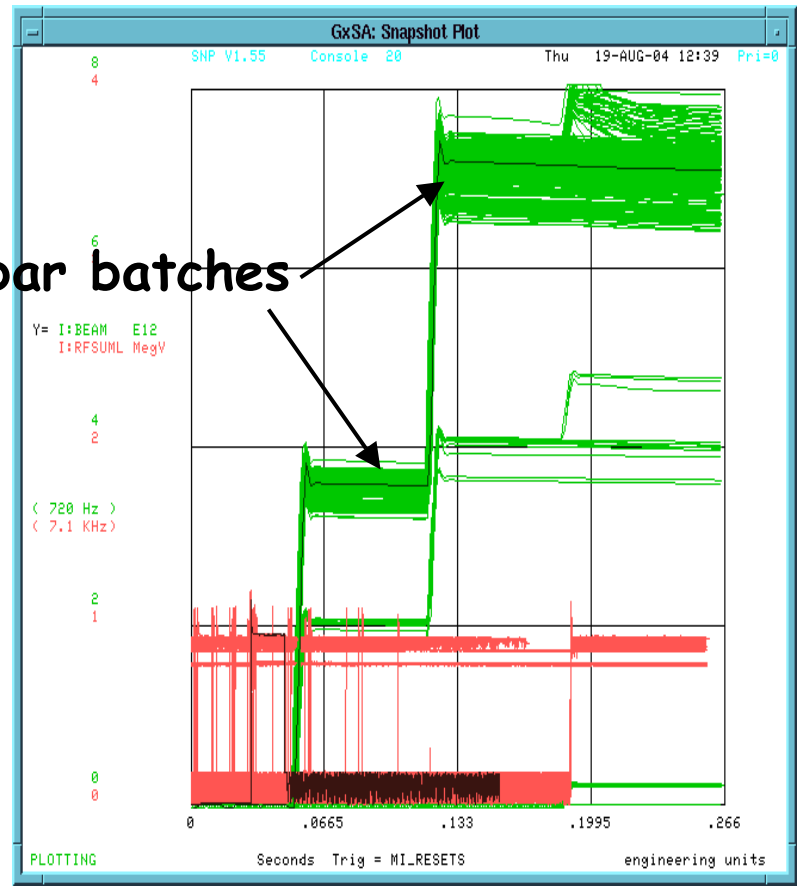
SY120

- **Modes of operation for slow spill to SY**
  - **Dedicated slow spill (initial mode)**
  - **Mixed-mode (single batch to pbar, 7/9)**
  - **Mixed-mode (2 batch slip-stacking to pbar, 8/19)**
- **Mixed-mode development required significant time and modifications**
- **Mixed-mode operation uses:**
  - **The same optics in P1 and P2 beamline for stacking and SY120**
  - **The same major dipole settings in P1/P2**
  - **Different dipole trim settings**
- **All three modes use same MI ramp and timing, but different TLG modules (easy to switch modes)**
- **All three modes have been commissioned**
- **The minimum cycle time 2.8 sec**
- **The spill length is 655 ms**

Switchyard 120 Mixed Modes



SY120 and Stacking



SY120 and Slip Stacking